WATER QUALITY DETERIORATION DUE TO ANTHROPOGENIC ACTIVITIES AND ITS IMPLICATION ON ENVIRONEMNT

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ABSTRACT

This study attempts to investigate the water quality by analyzing the available data from the secondary sources. The data presented in this study are extracted from various studies published in national and international journals. The study showed that drinking water quality is poorly managed and monitored in many countries, and there is a need for urgency to preserve the water body for the wellbeing of all living beings. Upon systematic review of the documents and data, the study infers that there is evidence that water sources, both surface and groundwater quality is deteriorating. The detection of excessive use of chemicals in agriculture farming, the physical and chemical test value beyond the WHO permissible limit, and the low density of Benthic Macroinvertebrates in the water body show that the water quality is deteriorating. Experts have a belief that destruction to the serenity of water resources is a real phenomenon due to anthropogenic activities. Human activities like improper disposal of municipal and industrial effluents and excessive use of agrochemicals in agriculture are the main factors contributing to the deterioration of water quality. A study suggests that for the humanity to be certain about their future, treating the water problem as an act of urgency and working towards mitigation by limiting the growth of population, expansion in industries, throwing away of wastewater and chemical effluents into canals are the plausible solution for better water quality in the future.

KEYWORDS: *Water quality, Waterborne diseases, Chemical fertilizers, Macroinvertebrates, Bioindicator, Physicochemical parameters*. *WHO standards,* Domestic *effluents.*

INTRODUCTION

Water is the most essential components of all living beings owing to the dependence of the existence of life on it. Living beings survive on food, food is produced by plants and the growth of plants depends on water. Without water, no creatures on the earth can survive and will put billions of lives at stake. However, the modernization of living style, influences by industrialization and technological-based farming over traditional farming practices, has led to the production of many hazardous substances that contaminate the water bodies. This might certainly threaten the survival of mankind and any other species that depend on its existence. Many nations recognize deterioration of water quality as a serious concern, and they started realizing the need for forming the associations and organizations to combat this issue. On the other hand, there are few cynical nations, owing to several reasons, consider the industrial development and technological approaches as a primary focus, overlooking the need for water quality as a less concern issue.

With time, the issue has become more apparent that the water we consume is becoming less safe and more toxic, it is very evident from the medical statistic observation that, a lot of people on daily basis suffer from water-borne diseases. Moreover, the implication of low water quality has given birth to the destruction of plants and aquatic lives. Therefore, it is of paramount importance that we monitor and make sure that the water remains at its natural existence, with less or no destruction. Many works of the literature suggest that deterioration of water quality is caused by the use of chemicals in the farming system. Scientific farming which anticipates the uses of chemicals is one of the main sources of nitrogen and phosphorus in surface waters, and their excess supply can result in eutrophication, impairing the health of ecosystems.

Pesticides that are applied to agricultural land have also been detected within water bodies, and there is increased concern over their potential impacts on non-target species, water quality, and human health (Talyor, 2017). It is also due to toxic gases emitted enormously by the manufacturing factories and automobiles industries, which pollute water bodies with its outlet waste.

It is the responsibility of all the global citizens to be mindful of the impact of water quality, and collaborate to find effective solutions to mitigate the problem that is ever going to be bigger as it gets delayed. It would be a grave mistake not to heed on this global immediate call, for this can restore our earth and eventually saving lives of billions that depend on

it. As a responsible global citizen, it is our moral obligation to explore the underlying truth and make informed decisions locally to address the problem. In doing so, the contribution is tremendous in creating a better environment, and the quality of water remains naturally on the earth's surface as required with no pollutants. It helps in creating a healthy and balanced ecosystem.

The intended objectives of this study are to identify which mitigation measures have potential benefits to reduce water pollution and improve water quality. It is also to highlight the importance of working towards prevention and mitigation by limiting the growth of population, fast urbanization, deforestation, expansion in industries, throwing away wastewater, and chemical effluents into canals that pollute the water body. Due to a lack of sufficient data and deficit in knowledge on water quality issues, many people are not aware of its implication, therefore to address this problem; this study is intended to provide a root cause of the issue, in creating awareness of the importance of taking care of water bodies. Through this finding, it is expected that the call for actions from global citizens to create water quality at its best natural, is well taken into consideration. The technically and industrialized dominated approaches triggered by monolithic practices have a much negative impact on the ecosystem, in particular the water bodies. Thus, this study will explore the available literature on water quality in terms of its urgency and uncover to audiences by responding to the following research questions:

1. What is the current state of water quality of surface water and groundwater?
2. Is drinking water quality deteriorating, and how urgent it is?
3. What causes the deterioration of water quality?
4. What are the preventive and mitigation measures to protect water quality?

SIGNIFICANCE OF THE STUDY

This study will be a significant endeavor in promoting clean drinking water, with required quality nutrients for human consumption. This study will provide recommendations on how safe is water to the human and environment in accordance with the World Health Organization guidelines. This study will also serve as a future reference for researchers on the subject of the importance of water quality management system.

The integrated findings from the various secondary sources of this study, intended to inform and remind the relevant stakeholders such as government, policymaker, chemical industry, farmers, and educators to ensure better quality water for all the generations to come. The study aims to reinforce the banned of extensive use of chemicals in the farmland. In addition, this study will also help to address the importance of putting appropriate interventions and preventive measures, to minimize water contaminations, and in uplifting the pristine environment.

REVIEW OF LITERATURE

The drinking water supply and its quality is priority one in public health, and indeed it is a basic need for all the living beings. Water delivered to the consumer that can be safely used for drinking, cooking, and washing is considered as potable drinking water. According to Dezuane (1997), potable water must meet the physical, chemical, bacteriological, and radionuclide parameters and should be delivered to the consumer through a protected distribution system in sufficient quantity. In addition, water should have palatability, be within reasonable limits of temperature, and possibly gain the confidence of the consumer.

Throughout human history, the search for clean, fresh, and palatable water has been man's priority. During the last twenty centuries, serious attempts have been made to serve communities with a sufficient amount of drinking water, but only during the last two centuries have criteria for acceptability been developed with the chemical and bacteriological examination to form the base standards (Dezuane, 1997). Therefore, the provision of safe drinking water will have a dramatic impact on public health and the lives of millions all over the world.

According to recent estimates, in developing regions of South Asia, Middle East, and Africa, the quality of drinking water is deteriorating rapidly due to high growth of population, fast urbanization, deforestation, expansion in industries, throwing away of wastewater and chemical effluents into canals

and other water sources (Mohsin, Safdar, Asghar, & Jamal, 2013). Water pollution is caused by an array of human activities, such as septic tanks, industrial waste, garden usage of chemicals, hydrocarbons from transport networks, and leaching from landfills, mines or quarries (Goel, 2006).

An increase in the use of fertilizers and crop protection chemicals along with livestock intensification over recent decades has led to the agricultural sector in many countries contributing to over 40% of the nitrates and phosphorus pollution in surface and coastal waters (OECD, 2008a). It is also the culprit for rising concentrations of sediment and chemical compounds found in many surface and ground waters (European Environment Agency, 2010; OECD, 2012a). Many cities in Asia are facing an increase in organic and nutrient material in drinking water due to the discharge of untreated domestic and industrial wastewater into these resources (Annachhatre, 2006).

According to the World Health Organization (WHO), approximately 1.1 billion people (in other words, one-sixth of the current world's population) lack access to safe water and 2.4 billion are without adequate sanitation. Over 2 million deaths a year are attributed to unsafe water, mostly due to waterborne diarrheal diseases. Ninety percent of those who die from diarrheal diseases are children in developing countries. The situation is more aggravated in South Asia, where more than 0.5 million deaths of infants happened per year with additional health threats due to poor water quality and bad sanitation.

For instance, in West Bengal (India) and some areas of Bangladesh, groundwater is contaminated with arsenic at levels as much as 70 times higher than the national drinking water standard of 0.05mg/l (UNEP, 1999). Worldwide, more people are dying from poor quality of water per year than from all forms of violence including war and it is estimated that about 26% of all deaths are the outcome from contagious diseases caused by pathogenic bacteria (WHO, 2002; UNEP GEMS/ Water Programme, 2008). Diarrhea, waterborne disease is reported as the leading cause of death in infants and children in the country while every fifth citizen suffers from illness and disease caused by the polluted water (Khalown et al., 2006).

Sources of water pollution are generally distinguished as a point or diffuse (also known as nonpoint). Pollutants from point sources are discharged directly into receiving waters such as sewage treatment works and industrial sites. Pollution from agriculture including runoff from fields and pollutants leaching into water systems from excessive application of agri-chemicals nutrients, pesticides, and other contaminants are considered as diffuse source (Environment Agency, 2004; Global Food Security, 2014a; OECD, 2012a.). Agriculture is estimated to contribute around 60% of nitrates, 25% of phosphorous (NAO, 2010; White and Hammond, 2009), and 75% of sediments in water bodies in the UK (Collins and Anthony, 2008).

The use of pesticides such as metaldehyde for eradicating slugs is also of great concern as water treatment methods struggle to remove such

chemicals from drinking water. Currently, 49% of surface drinking water protected areas are at risk due to such pesticides (Environment Agency,2015). During the 1990s, the water industry undertook some pesticide and nitrate removal schemes, resulting in the construction of 120 plants for pesticide removal and 30 for nitrate removal (Ofwat, 1998). Ofwat predicted capital expenditure for pesticides would fall to £88 million/yr, and for nitrate to £8.3 million/yr at the end of the 1990s (Pretty et al., 2000). However, in 2002 it was estimated that the water industry spent at least £225 million/yr to treat potable supplies of pesticides, nutrients, fecal organisms and suspended matter from soil erosion (Defra, 2002). Additional to the costs of treating water, there are associated risks to society, with pollution incidents compromising the provision of safe drinking water (United Utilities, 2015). With such issues occurring, a more upstream approach to pollution prevention has gained momentum in recent years.

The United Nations General Assembly proclaimed 1981–1990 as the International Drinking Water Supply and Sanitation Decade, with the objective of full access to water supply and sanitation for all people. During that time, the provision of safe water and sanitation was extended to hundreds of millions, at a cost exceeding $700 billion. Despite this major effort, however, the absolute number of people still lacking access to safe water and sanitation had not changed by much, though slight progress has been made in providing safe water to low-income urban populations, as well as those in rural areas (Mintz et al. 2001).

A study conducted in Pakistan's biggest city Karachi, out of hundreds of samples of water, not a single sample was found safe for drinking purposes (Ihsanullah, 2009). Furthermore, rapid population growth in urban areas poses problems in planning and constructing new water and sanitary infrastructures (Mintz et al. 2001). In several regions in Madagascar, the lack of safe drinking water is a major contributing factor to high rates of diarrhea and vulnerability to cholera (Dunston et al. 2001). In 1999, cholera was detected in Madagascar for the first time, after a long hiatus. The cholera outbreak caused more than 37000 illnesses and 2200 deaths.

Similarly, in the rural Nyanza province in Kenya, 66% of the population lacked access to safe water and nearly 50% of children younger than 5 years had experienced diarrhea in the preceding 2 weeks (Mong et al. 2001). Unfortunately, the intensity of waterborne diseases in developing countries is very high due to polluted drinking water. Resultantly, the rate of casualties particularly in infants is alarming. It is estimated that in Pakistan, about 230,000 infants (less than five-year-old) have been died each year due to waterborne diseases (Digitex, 2013). The treatment facilities of water are almost absent in rural and suburban areas and water is being contaminated through sewage, fertilizers use, decayed and leached organic matter, etc.

A wide variety of fatal diseases are associated with poor water quality i.e. diarrhea, cholera, typhoid, etc. Many of these diseases were being occurred by the use of infected groundwater. The experience in Madagascar and

Kenya showed that public health interventions must involve in achieving reductions in the incidence or severity of waterborne diseases such as diarrhea and cholera.

A study conducted by the American Society of Tropical Medicine and Hygiene (2007), found out that, in the Islamic colony, 16.1% residents were suffered from cholera, 7.2% in diarrhea, 6.3% in typhoid, 4.4% in jaundice and 2% people in kidney stone disease. This is mainly caused by the use of contaminated water. In Satellite town, 12.6% of inhabitants were suffered in diarrhea and a little portion of inhabitants suffered in kidney stone, typhoid, cholera, and jaundice. This is because of the better groundwater quality and healthy lifestyle of the inhabitants of Satellite town. In Shahdrah, 15.6% of residents were suffered in diarrhea, 3.8% in typhoid, 1.6% in kidney stone, and 1.1% of inhabitants were in cholera. It is analyzed that in the Islamic colony 36.0 % of residents were suffered from waterborne diseases because they were being used to bad quality water as they cannot afford bottled and filtered water. Due to this poor quality of water, waterborne diseases like diarrhea, cholera, typhoid, etc. were common in study areas particularly in the Islamic colony about 36% of residents have been facing serious diseases.

Despite the efforts put in by concern stakeholders in preserving water quality, the problem of water quality such as the lack of clean safe drinking water, even in countries where water is abundant, is one of the most serious challenges of our time**.** The evidence from the lack of safe drinking water,

multiple water-borne diseases, and contaminated water bodies by chemical waste indicate that water quality is deteriorating, and it is going to be a major threat in the coming future. This pertinent water-related issue is deemed urgency and shall be discussed in the result and data analysis section.

METHODOLOGY

The study utilized the qualitative method design and uses the document analysis approach of the data collected from the existing documented secondary sources. Resources were collected via the use of Google Scholar engine, mostly peer-review journals and accredited resources were used in finding the useable data. Data were collected from different secondary sources. Primarily the six main sources of the collected data include Journal articles as follows:

Journal title	Author (s) and year of publication
1. Assessment of Drinking Water Quality and its Impact on Residents' Health in Bahawalpur City.	by Mohsin, Safdar, Asghar, and Jamal, published in 2013.
2. Modeling the impacts of catchment mitigation measures on water quality.	by Sam David Taylor, published in 2017.
3. The water pollution abatement by the	by S. Dasgupta, M. Huq, D. Wheeler, and C. Zhang

Chinese industry: cost estimates and policy implications. 4. Factors Influencing Farmer Uptake of Water Pollution Mitigation Measures: The Role of Farm Advice. 5. Mitigation of diffuse water pollution from agriculture in England and China, and the scope for policy transfer. 6. The Bioassessment using Benthic Macroinvertebrates of the water quality in the Tigreiro river, and Jacuí Basin.	published in 1996. by Emilie Laura Vrain, published in 2015. by Laurence Smith and colleagues, published in 2016. by Carlos Eduardo Coppati and colleagues, published in 2013.

The data collection and analysis are done in response to the research question on “Is drinking water quality deteriorating, and how urgent it is?” Data from several water expert organizations such as the World Health Organization (WHO), International Water Association (IWA), and other accredited scientific journals are used for the same. The data from those separate sources were compared and analyzed. Owing to the lack of primary data no statistical software was employed for the analysis.

RESULTS AND DISCUSSIONS

Results from the analysis of three independent sets of observations viz use of fertilizers in agriculture farming, physical and chemical test parameters, and bioassessment using Benthic Macroinvertebrates, show that the surface water quality is deteriorating. In addition, results obtained from each of these independent sets of observations correlate and complement each other indicating the water pollution a real problem.

Use of Fertilizers in agriculture farming

The use of chemical fertilizers has increased in agricultural production, and crop yields have improved food security, but there are now concerns about the environmental impacts of the intensification of agriculture which leads to an increase in pollution of surface water and groundwater (Matson et al., 1997). This is evident in the 9.3-fold and 3.7-fold increase in nitrogen and phosphate fertilizer consumption, respectively, that occurred during the same period (International Fertilizer Association [IFA], 2016). The size of the global pesticide industry increased more than 124-fold from 1961-2013 (Figure 1) (FAO, 2016).

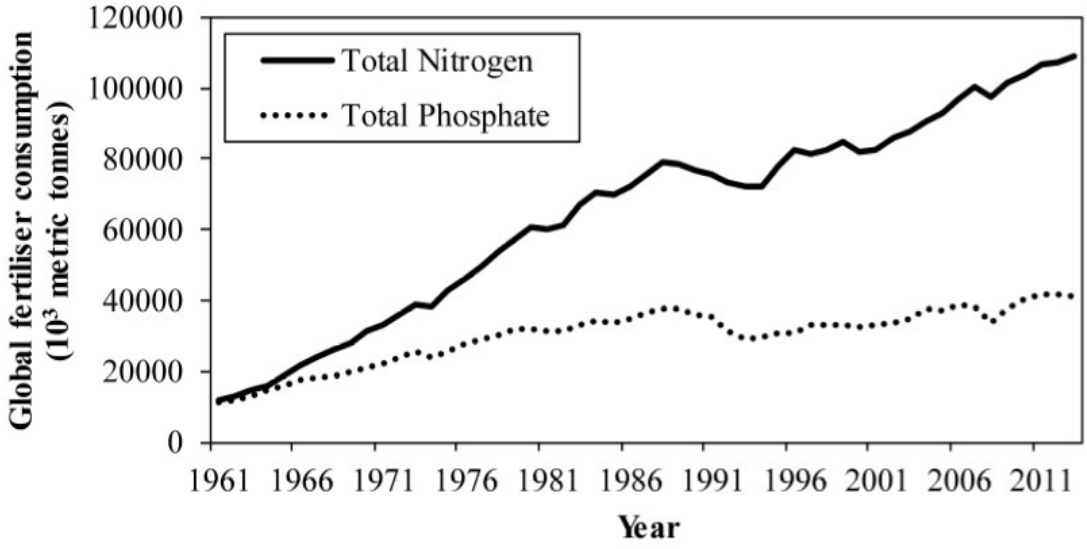

Figure 1: World nitrogen and phosphate fertilizer consumption from 1961-2013 (IFA, 2016).

Agriculture is a major source of diffuse pollution and is an important global pressure on surface water and groundwater quality (Carpenter et al., 1998; Vörösmarty et al., 2010; EEA, 2012; Solheim et al., 2012). In the EU,

diffuse pollution is pressure in 45% of surface water bodies whilst point source pollution is pressure in only 16% of surface water bodies (EEA, 2016a). For instance, nutrient enrichment that results in-part from agricultural diffuse water pollution is pressure in 52% and 56% of surface water bodies in the UK and Germany, respectively (EEA, 2016b).

Similarly, In the United States, diffuse pollution from agriculture is also the primary cause of water quality impairment in streams and the third most frequent cause of water quality impairment in lakes, ponds, and reservoirs (Environmental Protection Agency [EPA], 2009). Diffuse pollution is by far the largest source of nitrogen and phosphorus in surface waters in the United States, contributing 82% and 84% of total nitrogen and phosphorus loads, respectively (Figure 2) (Carpenter et al., 1998).

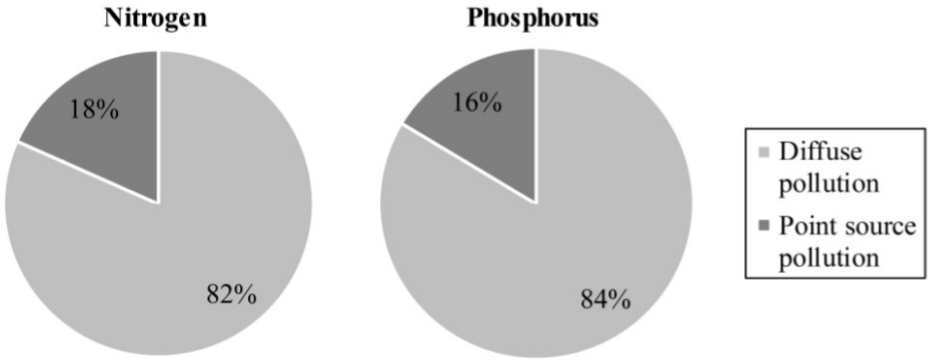

Figure 2: Diffuse and point source apportionment for total nitrogen and Phosphorus loads in surface waters in the United States (Carpenter et al., 1998).

Of this diffuse pollution, cropland is the largest source and is responsible for 48% of total nitrogen loads and 37% of the total phosphorus loads within surface waters (Figure 3 and Figure 4) (Carpenter et al., 1998).

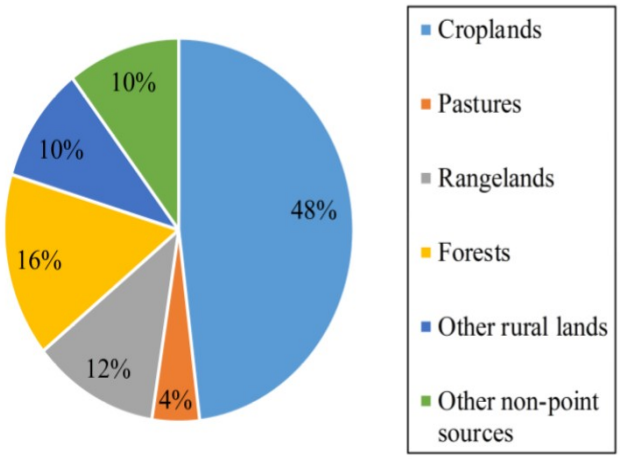

Figure 3: Source apportionment for diffuse nitrogen loads in surface waters in the United States (Carpenter et al., 1998)

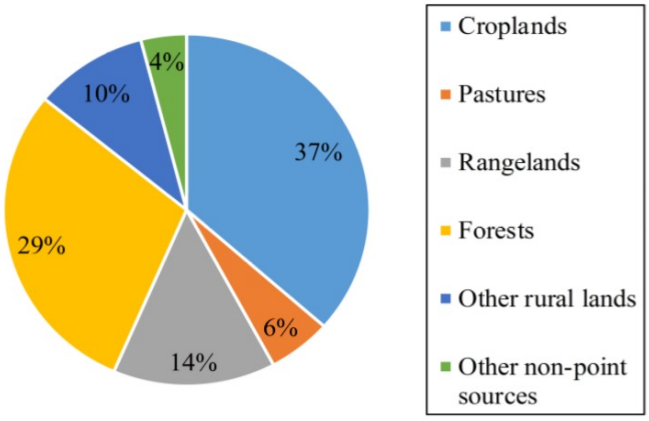

Figure 4: Source apportionment for diffuse Phosphorus loads in surface waters in the United States (Carpenter et al., 1998)

Moreover, In China water pollution remains severe with more than 61% of groundwater and 28% of surface waters in the main river basins

classified as unfit for human use or contact (China Water Risk, 2015). Agriculture is a major cause, estimated to be the source for 57% of the nitrogen and 69% of the phosphorus entering Chinese watercourses (MEP, 2010). Furthermore, In England, water pollutants from agriculture are sediment, chemicals, nitrate, and phosphorus, and its consequences are a source of increasing concern (Gov.UK, 2016a).

Figure 5: Drainage of fertilizers and pesticides into a stream, France *(Lamiot, 2003)*

Thus, data from all different sources show and depicts that there is a rapid degradation in water quality over the decade, due to the increasing use of fertilizers and pesticides. This hints at the deteriorating of water quality. Therefore, there is an urgent need to mitigate the impacts of agriculture on water quality.

Analysis of Physical and Chemical Parameters of Water

Water quality parameters provide important information about the health of a water body. A study conducted by the Pakistan Council of Research in Water Resources (PCRWR) tested water samples collected from Bahawalpur City for both physical and chemical parameters. Some of the important physical parameters that were tested included Total Dissolved Solids (TDS), Electrical Conductivity (EC), and pH of water. While, important chemical parameters tested were for Bicarbonates, Chloride, Sulfate, Magnesium, Calcium, Hardness, Sodium, Potassium, Alkalinity, and Nitrate. The results were then matched and discussed with WHO standards (WHO, 2011) (Table 1).

Table 1: Laboratory Analysis of Physical and Chemical Parameters of Study Areas and WHO Standards

Sample	Location	Parameters and Permissible Limit set by WHO												
		TDS (1000 ppm)	EC (400 µS/cm)	pH (6.5-8.5)	HCO_3 (500 mg/l)	Cl (250 mg/l)	SO_4 (250 mg/l)	Mg (150 mg/l)	Ca (75 mg/l)	Hardness (500 mg/l)	Na (200 mg/l)	K (12 mg/l)	Alk (500 mg/l)	NO_3 (10 mg/l)
1	Islamic Colony	290	467	7.2	225	16	33	36	26	195	36	7.5	181	4.5
2	Islamic Colony	595	930	7.3	320	66	106	66	40	330	93	5.2	289	6.4
3	Satellite Town	406	635	7.4	170	54	79	36	84	190	61	5.4	171	3.4
4	Satellite Town	694	1085	7.5	175	78	310	56	61	310	140	7.9	188	3.5
5	Shahdrah	401	627	7.4	180	51	72	58	29	265	33	5.5	277	3.6
6	Shahdrah	429	670	7.3	160	88	86	84	18	285	28	5.2	211	3.2

Source: Laboratory Analysis of Water Samples (2013)

As depicted on table 1, the finding from this study revealed that out of 13 parameters conducted, only 5 parameters such as Total Dissolved Solids (TDS), Bicarbonates (HCO_3), Chloride (Cl), Hardness, and Potassium (K)

level were found to be acceptable within the WHO standards. Whereas Electrical Conductivity (EC) was found high, which indicates that water in study areas was considerably ionized and has a higher level of ionic concentration. Similarly, the pH value was observed at 7.35-7.4. Hence, in study areas, the pH values were falling in the basic or alkaline range. The concentration of sulfate (SO_4) ranges from 33-106 mg/l in Islamic colony, 79-310 mg/l in Satellite town, and 72-86 mg/l in Shahdrah. The results exhibit that the concentration of sulfate in Satellite town was higher from the standard limit and may harmful for human health.

In addition, the quantity of magnesium (Mg) and sodium (Na) are significantly low in the Islamic colony as compare to Satellite town and Shahdrah. Such a low concentration somewhat affects the health of residents as it is essential for the human body. Moreover, alkalinity ranges from 181-289 mg/l in Islamic colony, 171-188 mg/l in Satellite town, and 277211 mg/l in Shahdrah. Thus, these values were under the permissible limit of WHO standards, 2011. However, the quantity of nitrate (NO_3) and Calcium (Ca) in Satellite town was exceeded the limit by WHO in water and posing threat on the health of inhabitants.

Moreover, a comparative study by India on seasonal variation in physicochemical characteristics in drinking water quality of Kanpur found that all seasons the surface water samples show higher values of pH, turbidity, TA, TDS, TH, Ca^{+2}, Mg^{+2}, Cl^{-}, $NO_{3-,}$ and $SO4^{-2}$. The study concluded that this quality deterioration in groundwater is due to various reasons like

the extent of pollution occurring due to urbanization and anthropogenic activities.

Another study on a comparative study of some physicochemical parameters of soil irrigated with sewage water and canal water of Dehradun city, India found out that the concentration of heavy metals in wastewater (Site I) is higher comparatively than natural water (Site II) irrigated soil. The concentrations of heavy metals were presented in (Table 2).

Table-2. Heavy metal concentration (mg kg¯1 dry weight) in two different Sites of DehraDun City,India.

Metals	Site-I	Site-II	Percentile increases and decreases	Tolerable limits	Indian standards
Pb	52.72±0.74	13.90±1.56	+279.16	100	250-500
Zn	264.09±3.05	64.07±3.06	+312.18	100	300-600
Cu	49.03±2.03	15.69±2.127	+212.49	300	135-270
Cd	24.66±1.87	11.16±3.27	+120.94	-	3-6

(All values are Mean ± SD. of 3 observations for each parameter)

In addition, a comparative study on the quality of groundwater sources of Riyadh and Al-Ahsa in Saudi Arabia found out that, most of the groundwater of Riyadh and Al-Ahsa regions were moderately saline, and contain a high quantity of chloride. Nitrate concentrations in both areas were higher than the normal range of groundwater. This indicates that these groundwaters are subject for contaminations by nitrate, due to the continuous expansion of agricultural development. Furthermore, a comparative study of drinking water quality parameters of three manmade

reservoirs i.e. Kolar, Kaliasote and Kerwa Dam in India, also indicates that in all the three water bodies, the total hardness, calcium hardness, and magnesium hardness were found to be beyond the permissible limits as prescribed by WHO standard. Thus, the data from the different studies for physical and chemical parameters form different locations indicates the quality of water is degrading in terms of both physical and Chemicals. This hints at the occurrence of deteriorating water quality.

Bioassessment using Benthic Macroinvertebrates of the Water Quality

The third confirmation of water quality degradation comes from bioassessment using benthic macroinvertebrates of the water quality. Benthic macroinvertebrates are the most common community used as a bioindicator of water quality (BONADA et al., 2006). A field investigation conducted in Tigreiro River (Brazil) for five sites at the Tigreiro river (Figure 6). The sites 1 (near the source) and 2 are located in the rural area, site 3 is located in the entrance to the urban area and sites 4 and 5 (near the mouth) are located in the urban area.

Figure 6: Sampling site at the Tigreiro river (Google earth, 2012)

The Rapid Ecological Assessment Protocol (REAP) of Callisto et al. (2002) and benthic biotic indices (% EPT [% EPT: % Ephemeroptera, Plecoptera and Trichoptera], BMWP-IAP [Biological Monitoring Work Party System by IAP (Instituto Ambient do Paraná)], ASPT [Average Score Per Taxon], SOMI [Development of the Serra dos Órgãos Multimetric Index]) applied in the study indicated that no site showed very good quality, but the site 2 has shown a good water quality for most parameters. The analysis of the indices used also revealed that sites 1, 3, 4, and 5 presented respectively regular, bad, very bad, and very bad water quality (Table 3).

Table 3: value of REAP and benthic biotic indices (% EPT, BMWP-IAP, ASPT and SOMI) in the Tigreiro river for water quality. G = Good. R = Regular. B = Bad. VB = Very Good. Values in parentheses refers to score

Index	Sites				
	1	2	3	4	5
REAP	R (54)	R (59)	B (36)	B (33)	B (35)
% EPT	B (18.05)	G (57.03)	B (21.65)	VB (0.78)	VB (0.84)
BMWP'-IAP	G (137)	G (148)	R (94)	VB (29)	VB (34)
ASPT	R (4.72)	G (5.10)	R (4.94)	VB (2.90)	B (3.78)
SOMI	R (18)	G (22)	VB (8)	VB (8)	VB (6)
Final evaluation	R	G	B	VB	VB

In the rural area (sites 1 and 2) there was no contamination evidenced. In the sites, 4 and 5, occurred the most worrisome values of microbiological variables. In this study, the % EPT orders showed severe situations in the Tigreiro river, except for site 2 (Table 3). Streams under urban influence receive considerable amounts of organic waste (ROY et al., 2003) that can influence the loss of water quality, as verified in the Tigreiro river.

These data reinforce the idea that the Tigreiro river presents eutrophic characteristics from the stretch it enters into the urban area, affecting the structure of benthic macroinvertebrates. Higher impacts are represented by raw domestic effluents discharged into the Tigreiro river. The Tigreiro river was impacted by human activities mainly in the urban area. It was demonstrated by a combination of different metrics to detect impacted sites and the consequence for the water quality.

According to Hering et al. (2006), benthic macroinvertebrates are more directly affected by oxygen condition and showed a significant response to eutrophication/organic pollution gradients in 185 streams in nine European countries, but responses to land use and hydromorphology were less strong. Urban streams have lower concentrations of dissolved oxygen and higher concentrations of ammonia, affecting the distribution and occurrence of the EPT orders (OMETTO et al., 2004). This was also verified in the above study (Table 3).

Moreover, a study was conducted on the tailrace of Dikhow River, India to assess the water quality of the river using the family biotic index. Assessment of water quality by using the family biotic index of macroinvertebrate reveals the poor water quality in the studied Dikhow river section (Dutta, Baruah, & Biswas, 2014). This indicates that the density of benthic macroinvertebrate has been decreased in that region due to increases in anthropogenic activities. Similarly, a study on evaluation of land use impact on river water quality using macroinvertebrates as a bioindicator in Lahumoko Watershed, Buton Island, Indonesia showed that individual abundance, family biotic index and diversity index parameters indicated that the water quality was worse in the middle and downstream of the watershed of the water body (Kahirun, Sabaruddin, & Mukhtar, 2019).

Furthermore, a study on the pre-impoundment macroinvertebrate composition of the Elemi river, Ado-Ekiti, Ekiti State, Nigeria found out that, the macroinvertebrate taxa recorded was characterized by low taxa

number in some tropical southwestern Nigeria streams and rivers (Edward et al,., 2015). They ascribed this low species diversity to some physicochemical conditions of water like fast flow, high pH, low dissolved oxygen, and conductivity. These factors probably disrupted life cycle, reproductive cycle, food chain, and migrations or imposed physiological stress on even the tolerant macroinvertebrates. Thus, form the past data shows that the water quality is deteriorating slowly, as indicated by the decrease in density of macroinvertebrate taxa in the water body.

CONCLUSION

The findings from the review indicate that the degradation in the quality of water and the rise in the chemical level is alarming due to anthropogenic activities. And the periodic monitoring and preventative measures are required to save the water from pollutions. There is no longer any doubt that the surface water and groundwater are getting contaminated due to the overuse of chemicals in farming. Moreover, the physical and chemical properties of water were found to be deteriorating over the years in many parts of the world. In some areas, because of water pollution, the density of macroinvertebrate taxa in the water body was found to be decreasing, which indicates the deterioration of water quality.

The studies from multiple sources revealed that anthropogenic activities such as improper disposal of municipal and industrial effluents, and excessive use of agrochemicals in agriculture farming are the

main factors responsible for the possible contamination with various metals into surface water and groundwater. The ecological and human impacts resulting from poor water quality are expected to include waterborne diseases, extinction of marine species, severe water shortages, growing casualties from natural disasters, and the destruction of plants. Due to the poor quality of water, waterborne diseases like diarrhea, cholera, typhoid, and others, were found common in contaminated water source areas.

The existing literature suggests based on the evidence of an increase in the agrichemicals, that it would be wise on the part of humanity to act on to combat water problems. Cause of water quality deteriorating is well documented and known by the majority of the people, what is failing, is in the action to minimize the production of chemical waste. Therefore, it is imperative to work towards prevention and mitigation by limiting the growth of population, fast urbanization, deforestation, expansion in industries, throwing away of wastewater and chemical effluents into canals which pollutes the water body.

RECOMMENDATIONS

The researcher identified a range of areas for attention concerning intervention and research. The following recommendations are based on study findings from secondary sources:

1. To rescue precious human lives from waterborne diseases, the water from contaminated sites should not be used for drinking without treatment.
2. Reduce the amount of chemicals used in agriculture farming, and sewer drains should be constructed away from water supply drains to avoid wastewater leaching in groundwater.
3. The awareness campaign on waterborne diseases and the importance of safe water for human health should be conducted by all the relevant stakeholders.
4. Water Quality Index (WQI) may be used as a tool to convey information regarding the quality of water easily and understandably to the public and policymakers.

The above recommendations are based on the findings from secondary sources. Owing to the lack of time and resources, the researcher could not collect primary data. However, the future researcher may explore possibilities to research this subject. In doing so, it will immensely help in understanding the water quality status in Bhutan.

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